ward and forward movement at regular intervals. On the animal or vegetable nature of the production he has no remarks to offer.

The paper was accompanied by magnified drawings of *Bacillaria paradoxa* in various stages of elongation and retraction; and by very highly magnified representations of its mode of fissiparous increase, and of the markings on both its surfaces.

Read also the commencement of a memoir "On the Vegetation of the Galapagos Archipelago, as compared with that of some other Tropical Islands and of the Continent of America." By Joseph Dalton Hooker, Esq., M.D., F.L.S. &c.

ROYAL INSTITUTION.

Jan. 29, 1847.—"On the fundamental type and homologies of the Vertebrate Skeleton." By Prof. Owen.

The Professor commenced by alluding to the origin of anatomy in the investigation of the human structure, in relation to the relief and cure of disease and injuries; and to the consequent creation of an anatomical nomenclature, having reference solely to the forms, proportions, likenesses and supposed functions of the parts of the human body; which were originally studied from an insulated point of view, and irrespective of any other animal structure or any common type. So, likewise, the veterinary surgeon had begun the study of the anatomy of the horse in an equally independent manner, and had given as arbitrary names to the parts which he observed. Thus, in the head of a horse there was the "os quadratum;" and in the foot the "cannon-bone," the "great" and "small pastern-bones," the "coronet," and "coffin-bones," &c. When the naturalist first sought to penetrate beneath the superficial characters of the objects of his study, their anatomy had often been conducted in the same insulated and irrelative way. The ornithotomist, or dissector of birds, described his "ossa homoidea," "ossa communicantia" seu "interarticularia," his "columella," his "os furcatorium" and "os quadratum," the latter being quite a distinct bone from the "os quadratum" of the hippotomist. The anatomiser of reptiles described "hatchet-bones" and "chevron-bones," an "os cinguliforme" or "os en ceinture," and an "os transversum;" he had also his "columella," but which was a bone distinct from that so called in the bird. The ichthyotomist described the "os discoideum," "os transversum," "os cœnosteon," "os mystaceum," "ossa symplectica," "prima," "secunda," "tertia," "quarta," &c. Each at first viewed his subject independently and irrelatively; and finding, therefore, apparently new organs, created a new and arbitrary nomenclature for them.

After pointing out the impediments to a philosophical knowledge of anatomy, from such disconnected attempts to master its complexities, and the almost impossibility of retaining in the memory such an enormous load of names, many distinct ones signifying the same essential part, whilst different parts had received the same name, Prof. Owen proceeded to demonstrate the principal results of the philoso-

phical researches of Cuvier, and other comparative anatomists, in tracing the same or homologous parts through the animal series, as they were exemplified in the osseous system, and principally in the bones of the head. When any bone in the human skull, for example, had been thus traced and determined in the skulls of the lower vertebrate animals, the same name was applied to it there as it bore in human anatomy, but understood in an arbitrary sense; and when the part had no name in human anatomy, but was indicated, as often happened, by a descriptive phrase, it received a name having a close relation to such phrase; and thus a uniform nomenclature had arisen out of the investigation of the homologies of the bones of the skeleton, applicable alike to the human subject, the quadruped, the bird, and the fish. The corresponding parts have been sometimes called *analogues*, and sometimes *homologues*; the latter being the appropriate term, since the parts are in fact namesakes. The essential difference between the relations of *analogy* and *homology* was illustrated by reference to a diagram of the skeletons of the ancient and modern flying dragons. The wings of the extinct pterodactyle were sustained by a modification of the bones of the fore-arm or pectoral limb, which bones were long and slender, like those of the bat; and one of the fingers, answering to our little finger, was enormously elongated. The wings of the little *Draco volans*, the species which now flits about the trees of the Indian tropics, were supported by its ribs, which were liberated from an attachment to a sternum, and were much elongated and attenuated for that purpose. The wing of the pterodactyle was *analogous* to the wing of the Draco, inasmuch as it had a similar relation of subserviency to flight; but it was not *homologous* with it, inasmuch as it was composed of distinct parts. The true homologue of the wing of the pterodactyle was the fore-leg of the little *Draco volans*.

The recognition of the same part in different species, Prof. Owen called the "determination of its special homology;" the recognition of its relation to a primary segment of the typical skeleton of the vertebrata, he called the "determination of its general homology." Before entering upon the higher generalization involved in the consideration of the common or fundamental type, Prof. Owen gave many illustrations of the extent to which the determination of special homologies had been carried, dwelling upon those which explained the nature and signification of the separate points of ossification at which some of the single cranial bones in anthropotomy began to be formed; as in the so-called "occipital," "sphenoid," and "temporal" bones. More than ninety per cent. of the bones in the human skeleton had had their namesakes or homologues recognized by common consent in the skeletons of all vertebrate animals; and Prof. Owen believed the differences of opinion on the small residuum capable, with one or two exceptions, of satisfactory adjustment. The question then naturally arose in the philosophic mind, upon what cause or condition does the existence of these relations of *special homology* depend? Upon this point the anatomical world was divided. The majority of existing authors on comparative ana-

tomy appeared either to have tacitly abandoned, or, with Cuvier and Agassiz, had directly opposed, the idea of the law of special homologies being included in a higher and more general law of uniformity of type, such as has been illustrated by the theory of the cranium consisting of a series of false or anchylosed vertebræ. Profs. De Blainville and Grant, however, teach the vertebral theory of the skull; the one adopting the four vertebræ of Bojanus and the gifted propounder of the theory, Oken; the other regarding the hypothesis of Geoffroy St. Hilaire of the cranial vertebræ as more conformable to nature. Prof. Carus of Dresden has beautifully illustrated the poet Goethe's idea of the skull being composed of six vertebræ. But these authors had left the objections of Cuvier and Agassiz unrebutted; and judging from the recent works of Profs. Wagner, Müller, Stannius, Hallmann, and others of the modern German school, and those of Milne Edwards, the doctrine of unity of organization, as illustrated by the vertebral theory of the skull, seemed to be on the decline on the Continent. To account for the law of special homologies on the hypothesis of the subserviency of the parts so determined to similar ends in different animals—to say that the same bones occur in them because they have to perform similar functions—involve many difficulties, and are opposed by numerous phænomena. Admitting that the multiplied points of ossification in the skull of the human fœtus facilitate, and were designed to facilitate, child-birth, yet something more than a final purpose lies beneath the fact, that all those points represent permanently distinct bones in the cold-blooded vertebrata. And again, the cranium of the bird, which is composed in the adult of a single bone, is ossified from the same number of points as in the human embryo, without any possibility of a similar final purpose being subserved thereby. Moreover, in the bird, as in the human subject, the different points of ossification have the same relative position and plan of arrangement as in the skull of the young crocodile; in which animal they always maintain, as in most fishes, their primitive distinctness. A few errors, some exaggerated transcendentalisms and metaphorical expressions of the earlier German homologists, and a too obvious tendency to *à-priori* assumptions and neglect of rigorous induction on the part of Geoffroy St. Hilaire, had afforded Cuvier apt subjects for the terse sarcasm and polished satire which he directed against the school of "Unity of Organization." The tone also which the discussions gradually assumed towards the latter period of the career of the two celebrated anatomists of the French Academy seems to have led to a prejudice in the mind of Cuvier against the entire theory and transcendental views generally; and he finally withdrew, in the second edition of his 'Leçons d'Anatomie Comparée,' that small degree of countenance to the vertebral theory of the skull which he had given by the admission of the three successive bony cinctures of the cranial cavity in the 'Règne Animal.'

Prof. Owen then briefly alluded to the researches which he had undertaken, with a view to obtain conviction as to the existence or otherwise of one determinate plan or type of the skeletons of the

vertebrata generally; and stated, that after many years' consideration given to the subject, he had convinced himself of the accuracy of the idea that the endo-skeleton of all vertebrate animals was arranged in a series of segments, succeeding each other in the direction of the axis of the body. For these segments or "osteocommata" of the endo-skeleton, he thought the term "vertebræ" might well be retained, although used in a somewhat wider sense than it is understood by a human anatomist. The parts of a typical vertebra were then defined, according to the views explained in the Professor's 'Lectures on Vertebrata'; and he proceeded to apply its characters to the four segments into which the cranial bones were naturally resolvable. The views of the lecturer were illustrated by diagrams of the disarticulated skulls of a fish, a bird, a marsupial quadruped, and the human fœtus. The common type was most closely adhered to in the fish, as belonging to that lowest class of vertebrata in which "vegetative repetition*" most prevailed, and the type was least obscured by modifications and combinations of parts for mutual subservience to special functions. The bones of the skull were arranged into four segments or vertebræ, answering to the four primary divisions of the brain, and to the nerves transmitted to the four organs of special sense seated in the head. Prof. Owen adopted the names which had been assigned to these vertebræ from the bones constituting their neural spines, viz. occipital, parietal, frontal, and nasal; and enumerated them from behind forwards, because, like the vertebræ of the tail, they lose their typical character as they recede from the common centre or trunk. The general results of the Professor's analysis may be thrown into the following tabular form:—

Primary Segments of the Skull-bones of the Endo-skeleton.

VERTEBRÆ.	OCCIPITAL.	PARIETAL.	FRONTAL.	NASAL.
Centrums.	Basioccipital.	Basisphenoid.	Presphenoid.	Vomer.
Neurapophyses.	Exoccipital.	Alisphenoid.	Orbitosphenoid.	Prefrontals.
Neural Spines.	Supraoccipital.	Parietal.	Frontal.	Nasal.
Parapophyses.	Paroccipital.	Mastoid.	Postfrontal.	None.
Pleurapophyses.	Scapula.	Stylohyal.	Tympanic.	Palatal.
Hæmapophyses.	Coracoid.	Ceratohyal.	Articular.	Maxillary.
Hæmal Spines.	Episternum.	Basihyal.	Dentary.	Premaxillary.
Diverging Appendage.	Fore-limb or fin.	Branchiostegals.	Operculum.	Pterygoids and Zygoma.

The upper or neural arch of the occipital vertebra protected the *epencephalon*, or medulla oblongata and cerebellum; that of the parietal vertebra protected the *mesencephalon*, or third ventricle, optic lobes, conarium and hypophysis; that of the frontal vertebra the *prosencephalon*, or cerebral hemispheres; that of the nasal vertebra the *rhinencephalon*, or olfactory crura and ganglions.

The superior development of the cerebral hemispheres in the warm-blooded class, and their enormous expansion in them, occasions corresponding development of the neural spines, not only of their proper vertebra, but, by their backward folding over the other primary segments, of those of all the other vertebræ; whilst the more important

* The general principle of animal organizations, which Prof. Owen has termed "the law of vegetative or irrelative repetition," is explained in the first volume of his 'Hunterian Lectures,—on the Invertebrate Animals.'

parts of the neural arch, as the neurapophyses, undergo comparatively little change.

The acoustic nerve escapes between the occipital and parietal vertebræ, but the organ itself is intercalated between the neural arches of these segments and its ossified capsule; the petrosal projects into the cranial cavity between the exoccipital and alisphenoid in the warm-blooded vertebrata. The gustatory nerve (part of the third division of the fifth pair) perforates or notches the alisphenoid, and in crocodiles and many fishes passes through an intervertebral foramen between the alisphenoid and orbitosphenoid; but the gustatory organ is far removed from the neural arches or cranium proper, and is united with its fellow to form the apparently single organ called the tongue. The optic nerve perforates or grooves the orbitosphenoid, and the eyeball intervenes between the frontal and nasal vertebræ, as the earball does between the occipital and parietal: the vertebral elements are modified to form cavities for these organs of sense; that lodging the eye being called the "orbit," that for the ear the "otocrane."

The divergence of the olfactory crura, and the absence of any union or commissure between the olfactory ganglia, leads to an extension of ossification from their neurapophyses, which are always perforated by the olfactory crura or nerves, to the median line between those parts; and the neurapophyses themselves coalesce together there in batrachia, birds and mammals. This extreme modification was to be expected in a vertebra forming the anterior extremity of the series; and the typical condition of the prefrontals, so well shown in fishes and saurians, is marked in mammals by the enormous development of the capsules of the organ of smell anterior to them, which become ossified and partially anchylosed to the compressed, shrunken and coalesced prefrontals; the whole forming the composite bone called "æthmoid" in anthropotomy. The vomer, or body of the nasal vertebra, has undergone an analogous modification to that which the terminal vertebra of the tail presents in birds; whence its special name, referring to the likeness to a ploughshare, in human anatomy. The spine, or nasal bone, is sometimes single, sometimes divided, like the frontal, the parietal and the supraoccipital bones. Their special adaptive modifications have obtained for them special names.

The hæmal arches corresponding with the above neural arches retain most of their natural position and proportions, as might be expected, in fishes; they are called the scapular, hyoid, mandibular and maxillary arches. The pleurapophysis of the occipital vertebra is the scapula, and is commonly attached by a head and tubercle to the centrum and parapophysis of its proper occipital vertebra.

The hyoid arch is suspended by the medium of the epitympanic to the mastoid parapophysis of the parietal vertebra, the epitympanic, in fishes, intervening and separating the hæmal arch from its proper vertebra, just as the squamosal intervenes to detach the tympanic pleurapophysis of the mandibular arch from its proper vertebra in mammals; which vertebra the squamosal attains in man by articu-

lating with the process representing the coalesced postfrontal. In return, we find the hyoidean arch resuming its normal connexions in many mammalia, the stylo-hyal element being directly articulated to the mastoid: in man the large petrosal capsule intervenes, and contracts that anchylosis with the proximal or pleurapophysial element of the hyoid arch, which has led to the description of the stylohyal as a process of the temporal bone, in works on human anatomy.

In fishes, the tympanic, which is the true pleurapophysis of the mandibular arch, always articulates with the postfrontal, besides its accessory joint with the mastoid. The maxillary arch is articulated by its pleurapophysis, the palatine bone, with the centrum and neurapophysis (vomer and prefontal) of the nasal vertebra. This is the normal and constant point of suspension of the maxillary arch; other accessory attachments to ensure its fixation and strength are successively superinduced upon this primary and essential one. Through this knowledge of the general homology of the palatine, an insight was gained into its singular disposition in man, creeping up, as it were, into the orbit, to touch the pars plana of the æthmoid; this secret affinity with the modified neurapophysis of the nasal vertebra becomes intelligible by a recognition of its relations to the general type of the vertebrate skeleton, by its determination as the rib or pleurapophysis of the nasal vertebra, and therefore retaining, as such, more or less of its essential connexion with the centrum (vomer) and neurapophyses (æthmoid or prefrontal) of the nasal vertebra throughout the vertebrate series.

The tympano-mandibular and the hyoidean arches had both been recognized as resembling ribs. A like homology of the scapula had early been detected by Oken; but its relation to the skull or occiput had been masked, and had escaped previous notice, by its displacement from its natural or typical connexions in all the air-breathing vertebrata.

The enunciation of these correspondences has sometimes been received by anatomists conversant with one particular modification of the general type, with as little favour as those of the "cannon-bone" to the metacarpus, of the "great and small pastern" and the "coffin-bones" to the digital phalanges of the human hand, may be supposed to have been by the earlier veterinarians.

Prof. Owen adduced instances of the displacement of different vertebral elements to subserve special exigencies, as that of the neurapophyses in the bird's sacrum, and that of the ribs in the human thorax, in which there could be, and had been, no question as to the reference of such displaced parts severally to their proper vertebral segments. The displacement of the scapular arch from the occiput was a modification of precisely the same kind, and differed only in degree. In the crocodile every cervical as well as every dorsal vertebra had its ribs; and in the immature animal the same elements existed, as distinct parts, in the lumbar, sacral, and in several caudal vertebræ. The occipital vertebra would be represented only by its "centrum" and "neural arch," unless the loose and obviously displaced scapulo-coracoid arch were recognized as its pleurapophysial

and hæmapophysial elements. This arch made its first appearance in every vertebrate embryo close to the occiput; and in fishes—the representatives of the embryo-state of higher vertebrata, where the principle of vegetative repetition most prevailed, and the primitive type was least obscured by teleological or adaptive modifications—the scapular arch retained its true and typical connexions with the occiput.

The general homology of the locomotive members, as developments of the diverging appendages of the inferior vertebral arches, was illustrated, and the parallelism in the course of the modifications of all such appendages pointed out. As the scapular arch belongs to the skull, so its appendages, the pectoral or anterior members, were essentially parts of the same division of the skeleton segments.

As a corollary to the generalization that the vertebrate skeleton consisted of a series of essentially similar segments, was the power of tracing the corresponding parts from segment to segment in the same skeleton. The study of such "serial homologies" had been commenced by the unfortunate Vicq. d'Azyr, in his memoir "on the parallelism of the fore and hind extremities;" and similar relations could be traced through the more important elements of the series of vertebræ. Prof. Owen believed it to be an appreciation of some of these homologies that lay at the bottom of the epithets, "scapula of the head," "ilium of the head," "femur of the head," &c. applied to certain cranial bones by Oken and Spix. To Cuvier this language had seemed unintelligible jargon; yet the error consisted merely in assigning a special instead of a general name to express the serial homology rightly discerned, in some of the instances, by the acute German anatomists. "Scapula," "ilium," "rib," &c. were names indicative of particular modifications of one and the same vertebral element. Such element, understood and spoken of in a general sense, ought to have a general name. Had Oken stated that the tympanic bone of the bird, for example, was a "pleurapophysis" (or by any other equivalent term) of the head, his language would not only have been accurate, but intelligible, perhaps, to Cuvier. When Oken called it the "scapula of the head," he then unduly extended such special name, and transferred it to a particularly and differently modified pleurapophysis, which equally required to have its own specific name.

Prof. Owen dwelt on the necessity of having clearly-defined terms for distinct ideas, in order to ensure the progress of science; and alluded to the advancement of human anatomy by accurate determinations of the general type, of which man's frame was a modification. —*From the Literary Gazette.*

BOTANICAL SOCIETY OF EDINBURGH.

January 14, 1847.—Sir William Jardine, Bart., in the Chair.

The following communications were read:—

1. "On Fairy Rings," by Dr. George Wilson. The object of Dr. Wilson's remarks was to show that the chemical theory of the